(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : 0 586 213 A1

(12) EUROPEAN PATENT APPLICATION

(21) Application number : 93306845.4

(22) Date of filing : 27.08.93

(51) Int. Cl.[5] : B29B 7/92, B27N 3/28, E04C 3/28, // B29K27:06, B29K105:12

(30) Priority : 01.09.92 US 938604

(43) Date of publication of application : 09.03.94 Bulletin 94/10

(84) Designated Contracting States : AT BE CH DE DK ES FR GB GR IE IT LI LU MC NL PT SE

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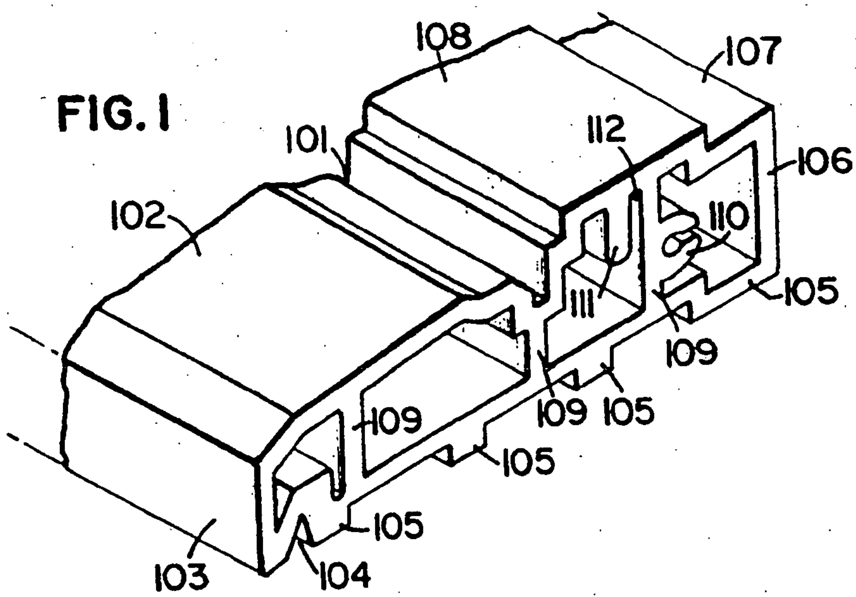
(54) Polymer and wood fibre composite structural member.

(57) A composite structural member, made of a polymer and wood fibre composite material, in the form of an extruded or injection moulded thermoplastic member in residential and commercial structures. The structural member can be used in a window or a door. The structural member has a hollow cross-section with at least one structural web (109) and at least one fastener web (110) formed within the member. The exterior of the extruded member is shaped and adapted for installation in a rough opening and to support window and door components. Such structural members can be assembled in a thermoplastic weld process. Welding is performed by heating and fusing the heated surfaces together to form a welded joint.

FIG. 1



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can be made with an intentional recycle of by product streams comprising thermoplastic, adhesive, paint, preservatives, etc., common in window manufacture. More particularly, the invention relates to improved materials adapted for extrusion into the structural members of windows and doors that have improved properties when compared to either metal or to clad and unclad wooden members. The structural members of the invention can be used in the form of rails, jambs, stiles, sills, tracks, stop and sash. The structural members of the invention can be heated and fused to form high strength welded joints in window and door assembly.Vinyl materials have been used in forming envelopes, trim and seal members in window units. Such vinyl materials typically comprise a major proportion of a vinyl polymer with inorganic pigment, fillers, lubricants, etc. Extruded or injection moulded thermoplastic materials have been used in window and door manufacture. Filled and unfilled flexible and rigid thermoplastic materials have been extruded or injection moulded into useful seals, trim members, fasteners, and other wood window construction parts.

The polyvinyl chloride used in the composite material can be polyvinyl chloride homopolymer free of additional ingredients or it can be polyvinyl chloride homopolymer, copolymer, etc., polyvinyl chloride alloy or any of the polymeric materials compounded with additional additives. The sawdust can be virgin sawdust or can comprise sawdust recycle from the wood manufacturing process. Typically, the composition comprises from at least about 30%, preferably at least about 35%, especially more than about 50% of the polyvinyl chloride material. The composition will comprise less than 70%, preferably less than about 65% of the polyvinyl chloride material. The composition will generally comprise at least about 30%, preferably at least about 35%, of the wood fibre material. The composition will generally comprise less than 55%, preferably less than 50%, of the wood fibre material. It can be preferred to use a composition which comprises approximately 60 wt % polyvinyl chloride with 40 wt % sawdust.

The extruded or injection moulded member can a linear member with a hollow profile.

The profile comprises an exterior wall or shell substantially enclosing a hollow interior. The interior can contain at least one structural web providing support for the walls and can contain at least one fastener anchor web to ensure that the composite member can be attached to other members using commonly available fasteners which are strongly retained by the fastener anchor web.

The structural member is typically shaped by the extrusion or injection moulding process such that the member can replace a structural or trim member of existing window or door manufacture. Such structural members can take a variety of shapes which surface contours are adapted to the window or door assembly process and are adapted to the operation of working parts of the window or door. Such structural members can contain screen insert supports, sliding window or sliding door supports, cut-outs for hardware installation, anchor locations, etc. The thermoplastic composite material typically forms a shell or wall exterior substantially surrounding the interior space. The exterior shell or wall contains a surface shaped as needed to assemble the window and surfaces needed for cooperation with the other working parts of the window and the rough opening as described above.

The interior of the structural member is commonly provided with one or more structural webs which in a direction of applied stress supports the structure. Structural web typically comprises a wall, post, support member, or other formed structural element which increases compressive strength, torsion strength, or other structural or mechanical property. Such structural web connects the adjacent or opposing surfaces of the interior of the structural member. More than one structural web can be placed to carry stress from surface to surface at the locations of the application of stress to protect the structural member from crushing, torsional failure or general breakage. Typically, such support webs are extruded or injection moulded during the manufacture of the structural material. However, a support can be post added from parts made during separate manufacturing operations.

The internal space of the structural member can also contain a fastener anchor or fastener installation support. Such an anchor or support means provides a locus for the introduction of a screw, nail, bolt or other fastener used in either assembling the unit or anchoring the unit to a rough opening in the commercial or residential structure. The anchor web typically is conformed to adapt itself to the geometry of the anchor and can simply comprise an angular opening in a formed composite structure, can comprise opposing surfaces having a gap or valley approximately equal to the screw thickness, can be geometrically formed to match a key or other lock mechanism, or can take the form of any commonly available automatic fastener means available to the window manufacturer from fastener or anchor parts manufactured by companies such as Amerock Corp., Illinois Tool Works and others.

The structural member of the invention can have premoulded paths or paths machined into the moulded thermoplastic composite for passage of door or window units, fasteners such as screws, nails, etc. Such paths can be counter sunk, metal lined, or otherwise adapted to the geometry or the composition of the fastener materials. The structural member can have mating surfaces premoulded in order to provide rapid assembly with other window members of similar or different compositions having similarly adapted mating surfaces. Fur-

101 over the snap-fit land 102, the exterior face 103 ending in the snap-fit groove 104 for a mechanically secure attachment. The sill rests on the subfloor supported by the sill rests 105. The interior installation face 106 abuts subflooring or trim additional members of the assembled sliding door unit. After the sliding door is installed an oak threshold is installed onto the oak threshold lands 107 and 108. The oak threshold has faces milled to match the threshold land areas. The interior of the sill shows vertical support webs 109. The support webs 109 provide compression strength supporting the top of the sill, the snap-fit lands 102 and the oak threshold lands 107 and 108. The sill also includes a C-shaped fastener anchor 110 which is moulded integrally with the support web 109. The typical fastener such as a screw can pass into the anchor space in the anchor 110. An additional attachment web 111 is coextruded with the oak threshold land 109 providing an attachment anchor valley 112 for screws passing vertically through the oak threshold land 108 into the valley screw anchor 112.

Fig. 2 shows a perspective view from below of an extruded sill member as shown in Fig. 1. The snap-fit attachment groove 101 for the aluminum sill, the snap-fit land 102 and the exterior face 103 is shown. The snap-fit groove 104 is shown on the bottom view. The sill rest members 105 are shown in the bottom view of the sill. The interior installation face 106 is hidden from sight. The oak threshold lands 107 and 108 are also hidden from view. The vertical support webs 109 are shown providing support for the oak threshold lands 107 and 108 and the snap-fit land 102. The fastener anchor 110 the vertical anchor web 111 and the fastener anchor valley 112 are also shown in the figure.

Fig. 3 is a perspective view from the side of a welded corner of a joint between two structural members that can be the exterior framing portion of a window or door unit. The top portion 301 and the wall portion 302 can be installed into a rough framed opening (not shown). The interior top surface 303 and 304 can have, installed plastic, wood or metal members for window or door operation. Such members can be sealed, weather stripped or similarly fixed in place. The structural integrity of the unit is obtained by welding the units at the weld line 305 which comprises a fused area that extends from the interior face 306 through the exterior face 307. The weld is finished using a heated tool mechanical routing or precision knife to create a surface 308 that forms an attractive finished look by heating the joined area on the exterior corner of the fused zone. Any irregularity caused by the expulsion of melted material from the fused zone is smoothed by forming the surface 308.

It has been found that joining a structural members can be accomplished using a melt fuse process. In the production of the joint shown in Fig. 3, the extruded member is first mitred to form a 45° cut. The mitred surface is then contacted with a heated member for sufficient period to melt the mitred joint to a depth of about 2 mm. The melt reaches a temperature greater than about melting point of the thermoplastic (i.e.,) about 225°C or more. A similar procedure is performed on the mating mitred surface. The melt mitred surfaces are joined in a fixed 90° angle position pressure is placed on the members until the melt mitred surfaces form a fused joint. The materials are held in place until the fused joint cools, solidifies and becomes mechanically sound. The formed joint is then removed from any mechanical restraints.

Figure 4 is an elevation of the structural member of the invention with an alternative fastener anchor. The member is identical to the member of figure 2 except in the fastener anchor. In Figure 4, a first anchor surface 401 and a second anchor surface 402 is used. These surfaces are included in webs 403 and 404 which act as support webs.

The structural member of the invention can be manufactured using any typical thermoplastic forming operation. Preferred forming processes include extrusion and injection moulding.

Pellet

The polyvinyl chloride and wood fibre can be combined and formed into a pellet using a thermoplastic extrusion process. A linear extrudate is similar to a pellet except the extrudate is not left in a linear format and is cut into discrete pellet units. Wood fibre can be introduced into a pellet making process in a number of sizes. We believe that the wood fibre should have a minimum size of length and width of at least 1 mm because smaller particles produce reduced physical properties in the member and because wood flour tends to be explosive at certain wood to air ratios. Further, wood fibre of appropriate size and an aspect ratio greater than 1 tends to increase the physical properties of the extruded structural member. However, useful structural members can be made with a fibre of very large size. Fibres that are up to 3 cm in length and 0.5 cm in thickness can be used as input to the pellet or linear extrudate manufacturing process. However, particles of this size do not produce highest surface quality structural members or maximized strength. The best appearing product with maximized structural properties are manufactured within a range of particle size as set forth below. Further, large particle wood fibre can be reduced in size by grinding or other similar processes that produce a fibre similar to sawdust having the stated dimensions and aspect ratio. One further advantage of manufacturing sawdust of the desired size is that the fibre material can be pre-dried before introduction into the pellet or linear

extruder direction resulting in improved structural properties in the sense of compression strength in response to a normal force or in a torsion or flexing mode.

The pellet dimensions are selected for both convenience in manufacturing and in optimizing the final properties of the extruded materials. A pellet that is with dimensions substantially less than the dimensions set forth above are difficult to extrude, pelletize and handle in storage. Pellets larger than the range recited are difficult to cool, introduce into extrusion equipment, melt and extrude into a finished structural member.

PVC Homopolymer, copolymers and polymeric alloys

Polyvinyl chloride is a common commodity thermoplastic polymer. Vinyl chloride monomer is made from a variety of different processes such as the reaction of acetylene and hydrogen chloride and the direct chlorination of ethylene. Polyvinyl chloride is typically manufactured by the free radical polymerization of vinyl chloride resulting in a useful thermoplastic polymer. After polymerization, polyvinyl chloride is commonly combined with thermal stabilizers, lubricants, plasticizers, organic and inorganic pigments, fillers, biocides, processing aids, flame retardants and other commonly available additive materials. Polyvinyl chloride can also be combined with other vinyl monomers in the manufacture of polyvinyl chloride copolymers. Such copolymers can be linear copolymers, branched copolymers, graft copolymers, random copolymers, regular repeating copolymers, block copolymers, etc. Monomers that can be combined with vinyl chloride to form vinyl chloride copolymers include a acrylonitrile, alpha-olefins such as ethylene, propylene, etc., chlorinated monomers such as vinylidene dichloride, acrylate monomers such as acrylic acid, methylacrylate, methylmethacrylate, acrylamide, hydroxyethyl acrylate, and others, styrenic monomers such as styrene, alphamethyl styrene, vinyl toluene, etc.; vinyl acetate; and other commonly available ethylenically unsaturated monomer compositions. Such monomers can be used in an amount of up to about 50 mol %, the balance being vinyl chloride. Polymer blends or polymer alloys can be useful in manufacturing the pellet or linear extrudate of the invention. Such alloys typically comprise two miscible polymers blended to form a uniform composition. Scientific and commercial progress in the area of polymer blends has lead to the realization that important physical property improvements can be made not by developing new polymer material but by forming miscible polymer blends or alloys. A polymer alloy at equilibrium comprises a mixture of two amorphous polymers existing as a single phase of inability mixed segments of the two macro molecular members. Miscible amorphous polymers form glasses upon sufficient cooling and a homogeneous or miscible polymer blend exhibits a single, composition dependent glass transition temperature (T_g), or as an immiscible or non-alloyed blend of polymers typically displays two or more glass transition temperatures associated with immiscible polymer phase. In the simplest cases, the properties of polymer alloys reflect a composition weighted average of properties possessed by the members. In general, however, the property dependence on composition varies in a complex way with a particular property, the nature of the members (glassy, rubbery or semi-crystalline), the thermodynamic state of the blend, and its mechanical state whether molecules and phases are oriented. Polyvinyl chloride forms a number of known polymer alloys including, for example, polyvinyl chloride/nitrile rubber; polyvinyl chloride and related chlorinated copolymers and terpolymers of polyvinyl chloride or vinylidine dichloride; polyvinyl chloride/alphamethyl styrene-acrylonitrile copolymer blends; polyvinyl chloride/polyethylene; polyvinyl chloride/chlorinated polyethylene and others.

The primary requirement for the substantially thermoplastic polymeric material is that it retain sufficient thermoplastic properties to permit melt blending with wood fibre, permit formation of linear extrudate pellets, and to permit the composition material or pellet to be extruded in a thermoplastic process forming the rigid structural member. Polyvinyl chloride homopolymers copolymers and polymer alloys are available from a number of manufacturers including B.F. Goodrich, Vista, Air Products, Occidental Chemicals, etc. Preferred polyvinyl chloride materials are polyvinyl chloride homopolymer having a molecular weight of about 90,000 ± 50,000, most preferably about 88,000 ± 10,000.

Wood fibre

Wood fibre, in terms of abundance and suitability can be derived from either soft woods or evergreens or from hard woods commonly known as broad leaf deciduous trees. Soft woods are generally preferred for fibre manufacture because the resulting fibres are longer, contain high percentages of lignin and lower percentages of hemicellulose than hard woods. While soft wood is the primary source of fibre for the invention, additional fibre make-up can be derived from a number of secondary or fibre reclaim sources including bamboo, rice, sugar cane, and recycled fibres from newspapers, boxes, computer printouts, etc.

However, the primary source for wood fibre of this invention comprises the wood fibre by-product of sawing or milling soft woods commonly known as sawdust or milling tailings. Such wood fibre has a regular reproducible shape and aspect ratio. The fibres based on a random selection of about 100 fibres are commonly at least

into a useful form.

The preferred equipment for mixing and extruding the composition and wood pellet of the invention is an industrial extruder device. Such extruders can be obtained from a variety of manufacturers including Cincinnati Millicron, etc.

The materials feed to the extruder can comprise from about 30 to 50 wt % of sawdust including recycled impurity along with from about 50 to 70 wt % of polyvinyl chloride polymer compositions. Preferably, about 35 to 45 wt % wood fibre or sawdust is combined with 65 to 55 wt % polyvinyl chloride homopolymer. The polyvinyl chloride feed is commonly in a small particulate size which can take the form of flake, pellet, powder, etc. Any polymer form can be used such that the polymer can be dry mixed with the sawdust to result in a substantially uniform pre-mix. The wood fibre or sawdust input can be derived from a number of plant locations including the sawdust resulting from rip or cross grain sawing, milling of wood products or the intentional commuting or fibre manufacture from wood scrap. Such materials can be used directly from the operations resulting in the wood fibre by-product or the by-products can be blended to form a blended product. Further, any wood fibre material alone, or in combination with other wood fibre materials, can be blended with a by-product stream from the manufacturer of wood windows as discussed above. The wood fibre or sawdust can be combined with other fibres and recycled in commonly available particulate handling equipment.

Polymer and wood fibre are then dry blended in appropriate proportions prior to introduction into blending equipment. Such blending steps can occur in separate powder handling equipment or the polymer fibre streams can be simultaneously introduced into the mixing station at appropriate feed ratios to ensure appropriate product composition.

In a preferred mode, the wood fibre is placed in a hopper, controlled by weight or by volume, to meter the sawdust at a desired volume while the polymer is introduced into a similar hopper have a volumetric metering input system. The volumes are adjusted to ensure that the composite material contains appropriate proportions on a weight basis of polymer and wood fibre. The fibres are introduced into a twin screw extrusion device. The extrusion device has a mixing section, a transport section and an extruder section. Each section has a desired heat profile resulting in a useful product. The materials are introduced into the extruder at a rate of about 600 to about 1000 pounds of material per hour and are initially heated to a temperature of about 215 to 225°C. In the intake section, the stage is maintained at about 215°C to 225°C. In the mixing section, the temperature of the twin screw mixing stage is staged beginning at a temperature of about 205 to 215°C leading to a final temperature in the melt section of about 195 to 205°C at spaced stages. One the material leaves the blending stage, it is introduced into a three stage extruder with a temperature in the initial section of 185 to 195°C wherein the mixed thermoplastic stream is divided into a number of cylindrical streams through a head section and extruded in a final zone of 195 to 200°C. Such head sections can contain a circular distribution of 10 to 500, preferably 20 to 250 orifices having a cross-sectional shape leading to the production of a regular cylindrical pellet. As the material is extruded from the head it is cut with a knife at a rotational speed of about 100 to 400 rpm resulting in the desired pellet length.

The composite thermoplastic material is then extruded or injection moulded into the structural members of the invention. Preferably, the composite composition is in the form of a pellet or linear extrudate which is directed into the extrusion or injection moulding apparatus. In extruder operations, the pellet materials of the invention are introduced into an extruder and extruded into the structural member of the invention. The extruder can be any conventional extruder equipment including Moldavia, Cincinnati Millicron Extruders, etc. Preferably, parallel twin screw extruders having an appropriate shaped four zone barrel are used. The extrudate product is typically extruded into a cooling water tank at a rate of about 4 feet of structural member per minute. A vacuum gauged device can be used to maintain accurate dimensions in the extrudate. The melt temperature in the extruder can be between 200 and 215°C (390 and 420°F). The melt in the extruder is commonly vented to remove water and the vent is operated at vacuum of not less than 3 inches of mercury. The extruder barrel has zones of temperature that decrease from a maximum of about 240°C to a minimum of between 180 and 190°C and four successive heating zones or steps.

Similarly, the structural members of the invention can be manufactured by injection moulding. Injection moulding processes inject thermoplastic materials at above the melt point under pressure into moulds having a shape desired for the final moulded products. The machines can be either reciprocating or two stage screw driven. Other machines that can be used are plunger mechanisms. Injection moulding produces parts in large volume with close tolerances. Parts can be moulded in combination of thermoplastic materials with glass, asbestos, taal carbon, metals and non-metals, etc. In injection moulding, material is fed from a hopper into a feed shoot into the mechanism used in the individual injection moulding apparatus to melt and place the melt injection material under pressure. The mechanism then uses a reciprocating screw, plunger or other injection means to force the melt under pressure into the mould. The pressure forces the material to take a shape substantially identical to that of the mould interior.

	COMPRESSION LOAD Fig 1 (kg)	COMPRESSION RETENTION Fig 2 (kg)	COMPRESSION RETENTION Fig 3 (kg)
Sill of Fig 1	1048	185	309
Pine	899	39	278

METHOD OF TESTING

Materials were extruded to the sill in Fig. 1.

Compression preparation and testing was done according to ASTM D143 sec. 79. The 22480.0 lb. load cell was used with a testing rate of 0.012 in/min to a maximum displacement of 0.1 in.

Screw retention preparation and testing was done according to ASTM D1761. The 2248.0 lb load cell was used with a testing rate of 0.01 in/min.

Thermal Properties

PURPOSE OF TEST

Evaluate the thermal transmittance of the sill member of Fig. 1, relative to the standard pine material, by monitoring interior subsill surface temperatures when the door exterior is exposed to cold temperature.

METHOD OF TESTING

The reclaimed composite sill was extruded to the profile indicated in Fig. 1. The material consists of a 40/60 wt % sawdust/PVC mixture.

A 118 cm (46.5 in) length of the reclaimed composite sill was used to replace one-half of the standard pine sill installed in the opening of the wind tunnel cold box. Installation flanges were fastened to the rough opening with duct tape. Fibreglass insulation was installed around the head and side jambs. Silicone sealant was applied beneath the sill and 1.9 cm (0.75 in) lumber was used as an interior trim at the head and side jambs.

CONCLUSION

The interior surface of the composite sill is about 1.1°C (2°F) colder than a pine sill (see Fig. 2) when the exterior temperatures is -23°C (-10°F) and a normal room temperature is maintained.

Neither pine nor the composite sill exhibited condensation at an interior relative humidity of about 25%.

Weld Cleave Strength

PART DESCRIPTION	MATERIAL	WALL THICKNESS (cm)	CLEAVE STRENGTH ($cm.kg^{-1}$) (s.d.)
Sill	PVC (100%)	0.38	1021 (38)
Sill	60% PVC 40% sawdust	0.38	382 (9)
Typical hollow PVC sash	PVC	0.2	365 (85)
Modified sill	60% PVC 40% sawdust	0.38	328 (47)
PERMASHIELD casement sash	PVC clad wood	0.12	168 (33)

The data that is set forth above shows that the composite sill manufactured from the polyvinyl chloride

and a shaped face adapted for a moveable window or door component.

12. A structural unit comprising at least two structural members as claimed in any one of claims 1 to 11, fixed together at a secure joint.

13. A structural unit as claimed in claim 12, in which the joint is formed by thermal welding.

14. A structural unit as claimed in claim 13, in which the joint is formed by means of a single unit inserted into each of the members.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 30 6845

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X	WO-A-90 08020 (POLYWOOD PATENT AB) * page 4, line 26 - line 29 * * page 5, line 3 - line 6 * * claims 1-7,9,10 * ---	1,6-10	B29B7/92 B27N3/28 E04C3/28 //B29K27:06, B29K105:12
Y A	US-A-4 056 591 (L. A. GOETTLER ET AL.) * column 1, line 9 - line 14 * * column 3, line 43 - line 50 * * column 3, line 56 - column 4, line 2 * * column 4, line 15 - line 16 * * column 10, line 22 - line 54 * * column 11; table 1 * ---	1-3, 6-10,12 4,5	
Y	US-A-3 349 538 (A. V. CROSSMAN) * column 2, line 36 - line 55; figure 5 * ---	1-3, 6-10,12	
A	GB-A-2 171 953 (H. MOLLER) * the whole document * ---	1,2,9,10	TECHNICAL FIELDS SEARCHED (Int.Cl.5)
A	US-A-4 102 106 (M. D. GOLDER ET AL.) * column 2, line 4 - line 33; figures 1,2 * ---	1,3,9, 10,12	E04C B27N B29B
A	GB-A-2 186 655 (H. MÖLLER) * the whole document * ---	1,9,10	
A	EP-A-0 062 533 (MONSANTO COMP.) * page 10, line 24 - line 30 * * page 13, line 24 - line 29 * ---	1,5,10	
A	FR-A-2 564 374 (GREPP) * the whole document * --- -/--	1,6-10	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	19 November 1993	FREGOSI, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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